SPECIFICATION

[Title of the Invention]

METHOD AND APPARATUS FOR MANAGING DEFECT USING TEMPORARY DFL AND TEMPORARY DDS INCLUDING DRIVE & DISC INFORMATION AND DISC THEREOF

[Brief Description of the Drawings]

FIG. 1 is a block diagram of a recording and/or reproducing apparatus according to a preferred embodiment of the present invention.

FIGS. 2A through 2D illustrate structures of a disc according to preferred embodiments of the present invention.

FIG. 3A illustrates a data structure of the disc shown in FIGS. 2A through 2D, according to a preferred embodiment of the present invention.

FIG. 3B illustrates a data structure of a disc with a drive & disc information area, a temporary defect management area (TDMA), and defect management areas (DMAs) as shown in FIG. 3A.

FIGS. 4A through 4D illustrate data structures of a TDMA where disc defect management has been performed, according to preferred embodiments of the present invention.

FIGS. 5A and 5B illustrate data structures of a TDMA where disc defect management is not performed, according to preferred embodiments of the present invention.

FIGS. 6A and 6B illustrate data structures of temporary defect management information *TDDS #i* according to preferred embodiments of the present invention.

FIG. 7 illustrates a data structure of a temporary defect information *TDFL #i* according to a preferred embodiment of the present invention.

FIGS. 8A and 8B illustrate data structures of a drive & disc information area according to preferred embodiments of the present invention.

FIG. 9 illustrates diagrams for explaining recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention.

FIG. 10 is a diagram illustrating an effective use of a data area according to the present invention.

FIG. 11 illustrates data structures of temporary defect information *TDFL #0* and *TDFL #1* according to the present invention.

FIG. 12 illustrates a data structure of information regarding defect #i.

FIG. 13 is a flowchart illustrating a disc defect management method according to a preferred embodiment of the present invention.

FIG. 14 is a flowchart illustrating a disc defect management method according to another embodiment of the present invention.

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art Prior to the Invention]

The present invention relates to disc defect management, and more particularly, to a disc with a temporary defect management area in which drive & disc information is recorded, and a disc defect management method and apparatus therefor.

Disc defect management is the process of rewriting data stored in a user data area of a disc in which a defect exists to a new portion of the disc's data area, thereby compensating for data loss caused by the defect. In general, disc defect management is performed using linear replacement or slipping replacement methods. In the linear replacement method, a user data area in which a defect exists is replaced with a spare data area having no defects. In the slipping replacement method, a user data area with the defect is slipped and the next user data area having no defects is used.

Both linear replacement and slipping replacement methods are, however, applicable only to discs such as a DVD-RAM/RW, on which data can be repeatedly recorded and recording can be performed using a random access method. In other words, the conventional linear replacement and slipping replacement methods cannot

be applied to write once discs on which recording is allowed only once. In general, the presence of defects in a disc is detected by recording data on the disc and confirming whether or not data has been recorded correctly on the disc. However, once the data is recorded on a write once disc, it is impossible to overwrite new data and manage defects therein.

After the development of a CD-R and a DVD-R, a high-density write once disc with a recording capacity of several dozen GBs has been introduced. This type of disc can be used as a backup disc since it is not expensive and allows random access that enables fast reading operations. However, disc defect management is not available for write once discs. Therefore, a backup operation may be discontinued when a defective area, i.e., an area where a defect exists, is detected during the backup operation. In general, the backup operation is performed when a system is not frequently used, e.g., at night when a system manager does not operate the system. In this case, it is more likely that the backup operation will be discontinued because a defective area of a write once disc is detected.

Meanwhile, when additional data will not be recorded on a recordable disc, i.e., when only data reproduction will be allowed, write protect information is recorded on the disc to prevent the data recorded on the disc from being mistakenly erased. However, once the write protect information is recorded, recording is not further allowed, and, thus, possible disc defects cannot be managed. That is, since recording is not allowed in a data area of the disc after recording of the write protect information, disc defect management cannot be performed.

[Technical Goal of the Invention]

The present invention provides a write once disc, and a disc defect management method and apparatus therefor.

The present invention also provides a write once disc and a disc defect management method and apparatus that can manage disc defects even when a disc defect is detected during a recording operation, allowing the recording operation to be

performed without interruption.

The present invention also provides a disc on which already-recorded write protect information can be changed, and a disc defect management method and apparatus therefor.

The present invention also provides a disc on which disc defect management is allowed even after recording of write protect information, and a disc defect management method and apparatus therefor.

The present invention also provides a disc, and a disc defect management method and apparatus that can increase reliability of data stored in a disc.

[Structure of the Invention]

According to an aspect of the present invention, there is provided a write once disc having a single record layer, wherein a lead-in area, a data area, and a lead-out area are sequentially positioned, the write once disc including a defect management area that is present in at least one of the lead-in area and the lead-out area, a temporary defect management area that is present in at least one of the lead-in area and the lead-out area, and a drive & disc information area that is present in at least one of the lead-in area and the lead-out area. Information regarding the locations of temporary defect information and temporary defect management information is recorded in the drive & disc information area, the temporary defect information and temporary defect management information, which includes drive & disc information, are recorded in the temporary defect management area, and temporary defect information and temporary defect management information, which are lastly recorded in the temporary defect management area, are recorded in the defect management area for disc finalization.

According to another aspect of the present invention, there is provided a write once disc having two record layers, wherein a lead-in area, a data area, and a lead-out area are sequentially positioned in a first record layer, and an outer area, a data area, and a lead-out area are sequentially positioned in a second record layer, the write once

disc comprising a defect management area in at least one of the lead-in area, the lead-out area, and the outer area; a temporary defect management area in at least one of the lead-in area, the lead-out area, and the outer area; and a drive & disc information area that is present in at least one of the lead-in area, the lead-out area, and the outer area. Here, temporary defect information and temporary defect management information, which includes drive & disc information, are recorded in the temporary defect management area, temporary defect information and temporary defect management information, which are lastly recorded in the temporary defect management area, are recorded in the defect management area, for disc finalization, and information regarding the locations of the temporary defect information and temporary defect management information is recorded in the drive & disc information area.

It is preferable that write protect information is further recorded in the drive & disc information area and recorded for every recording operation.

The drive & disc information preferably includes at least one of the write protect information and test location information.

According to yet another aspect of the present invention, there is provided a method of managing disc defects, the method including (a) recording information regarding a defect in data, which is recorded in a data area of a disc according to a first recording operation, as first temporary defect information several times in a temporary defect management area of the disc; (b) recording information for managing the first temporary defect information as first temporary defect management information in the temporary defect management area; (c) recording information regarding the locations of the temporary defect information and the temporary defect management information in a drive & disc information area of the disc; (d) repeating (a) through (c) at least once while increasing indexes given to the recording operation, the temporary defect information, and the temporary defect management information; and (e) recording lastly recorded temporary defect information and temporary defect management information in a defect management area of the disc for disc finalization.

The method preferably further includes (f) recording write protect information in

the drive & disc information area.

During (b), the first temporary defect management information is preferably recorded to include at least one of test location information and the write protect information.

According to still another aspect of the present invention, there is provided a recording and/or reproducing apparatus including a recording/reading unit that records data on or reads data from a disc; and a controller that controls the recording/reading unit to record information regarding a defect in data, which is recorded in a data area of the disc, as temporary defect information in a temporary defect management area; record management information for managing the temporary defect information as temporary defect management information in the temporary defect management area, the management information further including drive & disc information; record information regarding the locations of the temporary defect information and the temporary defect management information in a drive & disc information area of the disc; and record lastly recorded temporary defect information and temporary defect management information in a defect management area of the disc for disc finalization.

It is preferable that the controller controls the recording/reading unit to further record write protect information in the drive & disc information, controls the recording/reading unit to record the temporary defect information and the temporary defect management information for every recording operation, and controls the recording/reading unit to record the temporary defect management information to include test location information and write protect information for every recording operation.

Hereinafter, preferred embodiments of the present invention will be described in a greater detail with reference to the accompanying drawings.

FIG. 1 is a block diagram of a recording and/or reproducing apparatus according to a preferred embodiment of the present invention. Referring to FIG. 1, the recording apparatus includes a recording/reading unit 1, a controller 2, and a memory 3. The recording/reading unit 1 records data on a disc 100, which is an information storage

medium according to a preferred embodiment of the present invention, and reads back the data from the disc 100 to verify the accuracy of the recorded data. The controller 2 performs disc defect management according to the present invention and controls the recording/reading unit 1 to record write protect information on the disc 100. In this embodiment, the controller 2 uses a verify-after-write method in which data is recorded on the disc 100 in predetermined units of data and the accuracy of the recorded data is verified to detect if an area of the disc 100 has a defect. In other words, the controller 2 records user data on the disc 100 in units of recording operations and verifies the recorded user data to detect an area of the disc 100 in which a defect exists. Thereafter, the controller 2 creates information that indicates the position of the area with the defect and stores the created information in the memory 3. When the stored information reaches a predetermined amount, the controller 2 records the stored information as temporary defect information on the disc 100. If a user will not perform the disc defect management, the controller 2 records only temporary defect management information, which will be later explained, on the disc 100.

Here, the recording operation is an operation unit determined according to a user's intention or is a recording work to be performed. According to this embodiment, a recording operation indicates a process in which the disc 100 is loaded into the recording apparatus, data is recorded on the disc 100, and the disc 100 is taken out from the recording apparatus. During the recording operation, data is recorded and verified at least once; in general, data is recorded and verified several times. Defect information, which is obtained using the verify-after-write method, is temporarily stored as temporary defect information in the memory 3.

When a user presses the eject button (not shown) of the recording apparatus in order to remove the disc 100 after recording of data, the controller 2 expects a recording operation to be terminated. Next, the controller 2 reads the information from the memory 3, provides it to the recording/reading unit 1, and controls the recording/reading unit 1 to record it on the disc 100. Further, as will be explained later, information regarding the temporary defect information and the temporary defect management

information, and the write protect information are recorded in a drive & disc information area of the disc 100.

When the recording of data is completed, i.e., additional data will not be recorded on the disc 100 (the disc 100 needs to be finalized), the controller 2 controls the recording/reading unit 1 to rewrite the recorded temporary defect information and temporary defect management information to a defect management area (DMA) of the disc 100 as defect management information.

FIGS. 2A through 2D illustrate structures of the disc 100 of FIG. 1 according to preferred embodiments of the present invention. FIG. 2A illustrates in detail a disc 100 having a record layer *L0* (a single record layer disc). The disc 100 includes a lead-in area, a data area, and a lead-out area. The lead-in area is located in an inner part of the disc 100 and the lead-out area is located in an outer part of the disc 100. The data area is present between the lead-in area and the lead-out area and divided into a user data area and a spare area. The user data area is an area where user data is recorded. The spare area is a replacement area for a user data area having a defect, serving to compensate for loss in the recording area due to the defect. That is, the spare area is used for the disc defect management according to the present invention. In other words, when a defect exists in data recorded in the user data area, the data is recorded again in the spare area.

A data structure of the disc 100 shown in FIG. 2B is the same as that of the disc 100 of FIG. 2A except that a data area includes two spare areas. Therefore, a description of each area shown in FIG. 2B will be omitted. In FIG. 2B, the spare areas are located at the sides of the user data area. In this disclosure, the spare area between the lead-in area and the user data area will be referred to as an inner spare area and the spare area between the user data area and the lead-out area will be referred to as an outer spare area.

FIG. 2C illustrates a disc 100 having two record layers *L0* and *L1* (a double record layer disc). A lead-in area, a data area, and an outer area are sequentially

formed from the inner part of the first record layer *L0* to its outer part. Also, an outer area, a data area, and a lead-out area are sequentially formed from the outer part of the second record layer *L1* to its inner part. Unlike the single record layer discs shown in FIGS. 2A and 2B, the lead-out area is present in the inner part of the disc 100 of FIG. 2B. That is, the disc 100 of FIG. 2B has an opposite track path (OTP) in which data is recorded starting from the lead-in area of the first record layer *L0* toward its outer area and continuing from the outer area of the second record layer *L1* to its lead-out area. The spare area is allotted to each of the record layers *L0* and *L1*.

A data structure of the disc 100 shown in FIG. 2D is the same as that of the disc 100 of FIG. 2C, except that a first record layer *L0* and a second record layer *L1* further include a spare area. Therefore, a description of each area will be omitted here. The spare areas are formed at the sides of the user data areas of the first and second record layers *L0* and *L1*. In this disclosure, the spare areas adjacent to an inner part of the disc 100 will be referred to as inner spare areas and the spare areas adjacent to an outer part of the disc 100 will be referred to as outer spare areas.

If necessary, a portion of the user data area may be used as another spare area. The location of the spare area is not limited to the above description.

FIG. 3A illustrates structures of the disc 100 of FIG. 2, according to a preferred embodiment of the present invention. Referring to FIG. 3A, if the disc 100 is a single record layer disc, a drive & disc information area, a DMA, and a temporary DMA (TDMA) are present in at least one of the lead-in area and the lead-out area of the disc 100. If the disc 100 is a double record layer disc, the drive & disc information area, the DMA, and the TDMA are present in at least one of the lead-in area, the lead-out area, and the outer area.

If the disc 100 is a double record layer disc as shown in FIG. 2(c) or (d), the drive & disc information area, the DMA, and TDMA are preferably formed in the lead-in area and the lead-out area, which are located in the inner part of the disc 100, respectively.

In the drive & disc information area, there are recorded information regarding a drive used for a write and/or read operation, and information regarding a disc, e.g.,

whether the disc is a single record layer disc or a double record layer disc, and information regarding the location of a test area where recording conditions are tested. In particular, the disc information specifies disc defect management according to the present invention. For instance, the disc information may include location information regarding temporary defect information and temporary defect management information, and the write protect information. In general, information relating to managing disc defects in the disc 100 is recorded in the DMA. Such information includes the structure of the disc 100 for disc defect management, the recording position of defect information, whether defect management is performed or not, and the position and size of a spare area. In the TDMA, information regarding disc defects is recorded before disc finalization. The information regarding disc defects includes the drive & disc information, i.e., the information regarding the location of the test area and the write protect information.

In general, when a disc is loaded into a recording/reading apparatus, the apparatus reads data from a lead-in area and a lead-out area of the disc to determine how to manage the disc and record data on or read data from the disc. However, if the amount of data recorded in the lead-in area and/or the lead-out area increases, a longer time is spent on preparing the recording or reproducing of data after the loading of the disc. To solve this problem, the present invention uses temporary defect management information and temporary defect information that are to be recorded in a TDMA. The TDMA is allotted to the lead-in area and/or the lead-out area of a disc, being separated from the DMA. That is, when additional data will not be recorded on the disc, i.e., disc finalization is required, only lastly recorded defect information and defect management information are recorded in the DMA, thus enabling the recording/reading apparatus to read only the lastly recorded defect management information from the DMA. Accordingly, it is possible to accelerate disc initialization. Further, since the defect management information is recorded in a plurality of areas, the reliability of information can be increased.

According to the present invention, the defect management information, the

location information regarding the temporary defect information and the temporary defect management information, and the write protect information are recorded in the drive & disc information area. Accordingly, the recording/reading apparatus reads the location information from the drive & disc information area, and therefore, can access the DMA more rapidly based on the read location information. That is, the disc defect management can be more efficiently performed based on the location information.

Also, the drive & disc information including location information regarding the test area and the write protect information, is recorded in the temporary defect management information. Therefore, even if a disc drive does not access the drive & disc information area, the location information regarding the test area and the write protect information can be obtained from the temporary defect management area.

In this embodiment, since disc defect management is performed using the linear replacement method, the temporary defect information includes information indicating the position of an area of the disc 100 having a defect and information indicating the position of an area of the disc 100 that is replacement for the area having the defect. More preferably, the temporary defect information further includes information indicating whether the defect occurs in a single defect blocks or continuous defect blocks. The temporary defect management information is used to manage the temporary defect information and includes information indicating the position of the disc 100 where the temporary defect information is recorded. More preferably, the temporary defect management information further includes the location information regarding the test area and the write protect information. Detailed data structures of the temporary defect information and the temporary defect management information will be explained later.

In this embodiment, the temporary defect information and temporary defect management information are recorded every time when a recording operation ends. In the TDMA, information regarding a defect, which occurs in data recorded during recording operation #0, and information regarding a replacement area are recorded as temporary defect information #0, and information regarding a defect, which occurs in data recorded during recording operation #1, and information regarding a replacement

area are recorded as temporary defect information #1. Further, information for managing temporary defect information #0, #1, ... is recorded as temporary defect management information #0, #1, ... in the TDMA. When additional data cannot be recorded in the data area or a user does not wish to record additional data therein, i.e., the data needs to be finalized, temporary defect information recorded in a temporary defect information area and temporary defect management information recorded in a temporary defect management information area are rewritten to the DMA.

In this embodiment, all defect information contained in previously recorded temporary defect information #0, #1, #2,..., #i-1 is further contained in temporary defect information #i. Thus, it is easy to finalize the disc 100 just by reading defect information contained in lastly recorded temporary defect information #i and rewriting the read defect information to the DMA.

In the case of a high-density disc with a recording capacity of several dozens of GBs, it is desirable that a cluster is allocated to an area in which temporary defect management information #i is recorded and four to eight clusters are allocated to an area in which temporary defect information #i is recorded. This is because it is preferable to record new information in units of clusters to update information when a minimum physical unit of record is a cluster, although the amount of temporary defect information #i is just several KBs. A total amount of defects allowed in a disc is preferably about 5 % of the disc recording capacity. For instance, about four to eight clusters are required to record temporary defect information #i, considering that information regarding a defect is about 8 bytes long and the size of a cluster is 64 KBs.

The verify-after-write method can also be performed on temporary defect information #i and temporary defect management information #i. When a defect is detected, information recorded in an area of a disc having a defect may be either recorded in a spare area using the linear replacement method, or recorded in an area adjacent to the TDMA using the slipping replacement method.

In this disclosure, the drive & disc information area and the TDMA are separate areas but they may be formed as a single area. In the latter case, a part of the drive &

disc information, e.g., the location information regarding the test area and the write protect information, which needs to be updated is updated and recorded together with the temporary defect management information.

FIG. 3B illustrates a data structure of a disc with a drive & disc information area, a TDMA, and DMAs as shown in FIG. 3A. Referring to FIG. 3B, two DMAs *DMA 1* and *DMA 2* are formed to increase the robustness of defect management information, defect information, and write protect information. In FIG. 3B, *TDMA* denotes a temporary defect management area; *Test* denotes an area in which recording conditions of data are measured; *Drive and Disc information* is an area in which the drive & disc information is recorded and which is located beside a buffer area *Buffer 2* beside the DMA *DMA1*; and *Buffer 1*, *Buffer 2*, and *Buffer 3* are areas acting as buffers that indicate borders of the respective areas. A disc according to the present invention may include a plurality of drive & disc information areas.

FIGS. 4A through 4D illustrate data structures of a TDMA where disc defect management has been performed, according to preferred embodiments of the present invention.

Referring to FIG. 4A, a TDMA is logically divided into a temporary defect information area and a temporary defect management information area. In the temporary defect information area, temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... is sequentially recorded starting from the start of this area toward its end, such that the physical or logical addresses of the temporary defect information increase. The temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... is repeatedly recorded several times to increase the robustness of information. In particular, FIG. 4A illustrates recording of the temporary defect information *TDFL #0* P times. In the temporary defect management information area, temporary defect management information *TDDS #0*, *TDDS #1*, *TDDS #2*, ... is sequentially recorded starting from the start of this area. The temporary defect management information *TDDS #0*, *TDDS #1*, and *TDDS #2* correspond to the temporary defect information *TDFL #0*, *TDFL #1*, and *TDFL #2*, respectively.

Referring to FIG. 4B, compared to FIG. 4A, a DMA is also logically divided into a temporary defect information area and a temporary defect management information area, but the sequences of recording information are not the same. More specifically, in the temporary defect information area, temporary defect information *TDFL #0, TDFL #1, TDFL #2, ...* is sequentially recorded starting from the end of this area toward its start, such that the physical or logical addresses of the temporary defect information decrease. Similarly, the temporary defect information *TDFL #0, TDFL #1, TDFL #2, ...* is repeatedly recorded several times to increase the robustness of information. In particular, FIG. 4B illustrates recording of the temporary defect information *TDFL #0* P times. In the temporary defect management information area, temporary defect management information *TDDS #0, TDDS #1, TDDS #2, ...* is sequentially recorded starting from the end of this area. The temporary defect management information *TDDS #0, TDDS #1*, and *TDDS #2* correspond to the defect information *TDFL #0, TDFL #1*, and *TDFL #2*, respectively.

Referring to FIG. 4C, corresponding temporary defect information and temporary defect management information are recorded as pairs of information in a TDMA. More specifically, temporary management information *TDMA #0, TDMA #1, ...* is sequentially recorded starting from the start of the TDMA such that the physical or logical addresses of the temporary management information increase. The temporary management information *TDMA #0* contains a pair of corresponding temporary defect management *TDDS #0* and temporary defect information *TDFL #0,* and temporary management information *TDMA #1* contains a pair of corresponding temporary defect management information *TDDS #1* and temporary defect information *TDFL #1*. The temporary defect information *TDFL #0, TDFL #1, TDFL #2, ...* are repeatedly recorded several times to increase the robustness of information. In particular, FIG. 4C illustrates recording of the temporary defect information *TDFL #0* P times.

Referring to FIG. 4D, compared to the TDMA of FIG. 4C, corresponding temporary defect information and temporary defect management information are recorded as pairs of information in a TDMA, but the sequence of recording the

information is not the same. More specifically, in the TDMA, temporary management information *TDMA #0*, *TDMA #1*, ... is sequentially recorded starting from the end of the TDMA such that the physical or logical addresses of the temporary management information decrease. The temporary management information *TDMA #0* contains a pair of corresponding temporary defect management information *TDDS #0* and temporary defect information *TDFL #0*, and the temporary management information *TDMA #1* contains a pair of corresponding temporary defect management information *TDDS #1* and temporary defect information *TDFL #1*. Similarly, the temporary defect information *TDFL #0*, *TDFL #1*, *TDFL #2*, ... is repeatedly recorded several times to increase the robustness of information. In particular, FIG. 4D illustrates recording of the temporary defect information *TDFL #0* P times.

FIGS. 5A and 5B illustrate data structures of a TDMA where disc defect management is not performed, according to preferred embodiments of the present invention.

Referring to FIG. 5A, when a user decides not to perform disc defect management, temporary defect management information is recorded in the TDMA in recording operation units. More specifically, temporary defect management information *TDDS #0*, *TDDS #1*, ... is recorded starting from the start of the TDMA such that the physical or logical addresses of the temporary defect management information increase.

Referring to FIG. 5B, when the user decides not to perform disc defect management, temporary defect management information is recorded in the TDMA in recording operation units. However, unlike in the FIG. 5A, temporary defect management information starting from the *TDDS #0*, *TDDS #1*, ... is recorded starting from the end of the TDMA such that the physical or logical addresses of the temporary defect management information decrease.

FIGS. 6A and 6B illustrate data structures of temporary defect management information *TDDS #i*.

In detail, FIG. 6A illustrates a data structure of temporary defect management information *TDDS #i* recorded on a single record layer disc. The temporary defect

management information *TDDS #i* contains an identifier for temporary defect management information *TDDS #i*, and information regarding the position of corresponding temporary defect information *TDFL #i*. As previously explained with reference to FIGS. 4A through 4D, temporary defect information *TDFL #i* according to the present invention is repeatedly recorded several times, and thus, the information regarding the position of temporary defect information *TDFL #i* includes pointers corresponding to temporary defect information *TDFL #i*, each pointer to the recording position of each temporary defect information *TDFL #i*. Temporary defect management information *TDDS #i* shown in FIG. 5A includes P pointers to temporary defect information *TDFL #i* recorded P times.

Also, temporary defect management information *TDDS #i* recorded on a single record layer disc describes the address of user data, which is lastly recorded in a user data area of a record layer *L0*, and the address of replacement which is lastly recorded in a spare area of the record layer *L0*. Accordingly, a user can easily utilize the disc just by referring to the lastly recorded user data and replacement.

The temporary defect management information *TDDS #i* further includes test location information #i and write protect information #i. Accordingly, even if a disc drive does not access the drive & disc information area or the disc defect management is not performed, it is possible to directly access a testable area without detecting the testable area while scanning the test area where recording conditions are tested. Also, it is possible to avoid recording in an undesired area.

FIG. 6B illustrates a data structure of temporary defect management information *TDDS #i* recorded on a double record layer disc. Temporary defect management information *TDDS #i* contains an identifier for the temporary defect management information *TDDS #i*, and information regarding the recording position of corresponding temporary defect information *TDFL #i*. As previously mentioned with reference to FIGS. 4A through 4D, temporary defect information *TDFL #i* according to the present invention is repeatedly recorded several times, and thus, the information regarding the recording position of the temporary defect information *TDFL #i* contains pointers to the recording

positions of respective temporary defect information *TDFL #i*. In particular, the temporary defect management information *TDDS #i* shown in FIG. 5B includes P pointers, each pointer to each of temporary defect information *TDFL #i* that is repeatedly recorded P times.

Also, the temporary defect management information *TDDS #i* recorded on a double record layer disc describes the address of user data that is lastly recorded in a user data area of a first record layer *L0*, the address of replacement that is lastly recorded in a spare area of the first record layer *L0*, the address of user data that is lastly recorded in a user data area of a second record layer *L1*, and the address of replacement that is lastly recorded in a spare area of the second record layer L1. Accordingly, a user can easily utilize the disc just by referring to the lastly recorded user data and replacement.

Similarly to a single record layer disc, the temporary defect management information *TDDS #i* further includes test location information #i and write protect information #i. Accordingly, even if a disc drive does not access the drive & disc information area or the disc defect management is not performed, it is possible to directly access a testable area without detecting the testable area while scanning the test area where recording conditions are measured. Also, it is possible to avoid recording in an undesired area.

FIG. 7 illustrates a data structure of temporary defect information *TDFL #i*. Referring to FIG. 6, temporary defect information *TDFL #i* contains an identifier for temporary detect information *TDFL #i*, and information regarding defects #1, #2, .. , #k. The information regarding defects #1, #2, .. , #k is state information indicating the positions of defects and replacements, and whether a defective area includes a single defect block or continuous defect blocks.

FIGS. 8A and 8B illustrate data structures of a drive & disc information area according to preferred embodiments of the present invention.

Referring to FIG. 8A, write protect information #i, a pointer to the location of temporary defect information *TDFL #i*, and a pointer to the location of temporary defect

management information *TDDS #i* are recorded in recording operation units in the drive & disc information area, when the temporary defect information *TDFL #i* and the temporary defect management information *TDDS #i* are separately recorded in a TDMA as shown in FIG. 4A or 4B.

Referring to FIG. 8B, write protect information *#i* and a pointer to the location of temporary management information *TDMA #i* are recorded in recording operation units in the drive & disc information area, when the temporary defect information *TDFL #i* and temporary defect management information *TDDS #i* are recorded to be included in the temporary management information *TDMA #i* in a TDMA as shown in FIG. 4C or 4D.

According to the present invention, the write protect information, which is recorded in the drive & disc information area and the temporary defect management information *TDDS #i*, does not allow additional data to be recorded on the disc 100. The write protect information may include flag information that indicates whether write protection is enabled or disabled on the entire disc 100, and information that indicates recordable areas even if write protection is enabled. For instance, a first bit of the write protect information is set as the flag information that indicates whether write protection is enabled or disabled, and each of the other bits is set to indicate whether at least one predetermined area is recordable or not. If the write protection is enabled, a second bit of the write protect information may indicate whether the drive & disc information area is recordable or not. Otherwise, the second 3 bit may indicate whether the drive & disc information area is recordable or not and a third bit may indicate whether a DMA is recordable or not. The third and fourth bits may indicate whether the DMA and a spare area are recordable or not.

When the write protect information is recorded, the following areas can be recordable.

First, data recording is allowed in the drive & disc information area, even if the write protect information is recorded on the disc 100 and additional data cannot be further recorded. In other words, the drive & disc information area is not affected by the write protect information recorded to enable write protection. Accordingly, it is

possible to change the write protect information.

Second, even if the write protect information is recorded to enable write protection, a part of the drive & disc information area allocated for the write protect information is not affected by the write protection. In other words, data recording is allowed in the part of the drive & disc information area, and thus, the write protect information can be changed.

Third, even if the write protect information is recorded to enable write protection, a defect management area (DMA), the drive & disc information area, and a spare area are not affected by the write protection, that is, data recording is allowed in these areas. Thus, the write protect information can be changed, and further, disc defect management can be performed even after recording of the write protect information. If a rate of error correction in a data block of a user data area is lower than a predetermined reference value when reproducing data stored in the user data area, disc defect management can be performed such that the data block is regarded as an area where the probability of error occurrence is higher, data stored in the data block is rewritten to the spare area before reproduction of the data, and the data block is determined to be a defective area.

If the disc 100 includes more than a spare area, at least one area of the spare areas is determined to be a recordable area.

Areas in which data recording is allowed even if the write protect information is recorded, are not limited to the above description, that is, the number and type of the areas can be adjusted if necessary.

FIG. 9 is a reference diagram illustrating in detail recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention.

Data can be processed in units of sectors or clusters. A sector denotes a minimum unit of data that can be managed in a file system of a computer or in an application, and a cluster denotes a minimum unit of data that can be physically recorded on a disc at once. In general, one or more sectors constitute a cluster.

There are two types of sectors: a physical sector and a logical sector. The physical sector is an area on a disc where a sector of data is to be recorded. An address for detecting the physical sector is called a physical sector number (PSN). The logical sector is a unit in which data can be managed in a file system or an application. An address for detecting the logical sector is called a logical sector number (LSN). A disc recording/reading apparatus detects the recording position of data on a disc using a PSN. In a computer or a data application, the entire data is managed in units of LSNs and the position of data is detected using an LSN. The relationship between an LSN and a PSN is changed by a controller of the recording/reading apparatus, based on whether or not the disc contains a defect and an initial position of recording data.

Referring to FIG. 9, *A* denotes a user data area and *B* denotes a spare area in which PSNs are sequentially allocated to a plurality of sectors (not shown). In general, each LSN corresponds to at least one PSN. However, since LSNs are allocated to non-defective areas, including replacements recorded in the spare area, the correspondence between the PSNs and the LSNs is not maintained when a disc has a defective area, even if the size of a physical sector is the same as that of a logical sector.

In the user data area *A*, user data is recorded either in a continuous recording mode or a random recording mode. In the continuous recording mode, user data is recorded sequentially and continuously. In the random recording mode, user data is randomly recorded. In the data area *A*, sections ① through ⑦ denote predetermined units of data in which the verify-after-write method is performed. A recording and/or reproducing apparatus records user data in section ①, returns to the start of section ①, and checks if the user data is appropriately recorded or a defect exists in section ①. If a defect is detected in a portion of section ①, the portion is designated as defect #1. The user data recorded in defect #1 is also recorded on a portion of the spare area *B*. Here, the portion of the spare area *B* in which data recorded in defect #1 is rewritten is called replacement #1. Next, the recording and/or reproducing apparatus records user data in section ②, returns to the start of section ②, and checks whether the data is

properly recorded or a defect exists in section ②. If a defect is detected in a portion of section ②, the portion is designated as defect #2. Likewise, replacement #2 corresponding to defect #2 is formed in the spare area *B*. Further, defect #3 and replacement #3 are designated in section ③ of the user data area *A* and the spare area *B*, respectively. In section ④, a defect does not occur and a defective area is not designated.

The recording and/or reproducing apparatus records information regarding defect #1, #2, and #3 occurring in sections ① through ④ as temporary defect information *TDFL #0* in a TDMA, when recording operation #0 is expected to end, after the recording and verifying of data to section ④, i.e., when a user presses the eject button of a recording apparatus or recording of user data allocated in a recording operation is complete. Also, management information for managing temporary defect information *TDFL #0* is recorded as temporary defect management information *TDDS #0* in the TDMA.

When recording operation #1 starts, data is recorded in sections ⑤ through ⑦ and defects #4 and #5 and replacements #4 and #5 are formed in the user data area *A* and the spare area *B*, respectively, as explained in sections ① through ④. Defects #1, #2, #3, and #4 occur in the single blocks, whereas defect #5 occurs in continuous defect blocks. Replacement #5, which is replacement for defect #5, is recorded in continuous replacement blocks. Here, a block refers to a physical or logical record unit, a range of a unit block being not limited. If the second recording operation is expected to end, the recording apparatus records information regarding defects #4 and #5 as temporary defect information *TDFL #1*, and records the information contained in the defect information *DFL #1* once again. Thereafter, management information for managing temporary defect information *TDFL #1* is recorded as temporary defect management information #1 in the TDMA.

For disc finalization, temporary defect information and temporary defect management information that are lastly recorded in the TDMA, are recorded as defect information and defect management information in a defect management area (DMA),

respectively. Also, information regarding the recording positions of the lastly recorded temporary defect information and temporary defect management information, and the above write protect information are further recorded in the TDMA.

FIG. 10 is a diagram illustrating an effective use of a user data area according to the present invention. FIG. 10 reveals that an available portion of a user data area can easily be detected with the address of user data that is lastly recorded in the user data area and the address of replacement that is lastly recorded in the spare area. In particular, the available portion can be more easily detected when the user data is recorded from the inner part/outer part of the user data area to its outer part/inner part and data, which is a replacement for a defect, is recorded from the outer part/inner part of the spare area to its inner part/outer part, respectively. In other words, the user data and the data for replacement are preferably recorded in opposite recording directions.

When physical addresses of user data are increased from the inner part of the record layer *L0* to the outer part and increased from the outer part of the record layer *L1* to the inner part, a physical address of the data, which is lastly recorded in the user data areas of record layers *L0* and *L1*, has the largest number. Also, lastly recorded replacement has a physical address with the smallest number, when physical addresses of replacements are reduced from the outer part to the inner part in a spare area of the record layer *L0* and increased from the inner part to the outer part in a spare area of the record layer *L1*.

Accordingly, as previously mentioned, if the addresses of the lastly recorded data and replacement are included in temporary defect management information *TDDS #i*, it is possible to detect the positions of data and replacement that are to be newly recorded, without completely reading temporary defect information *TDFL #i* and estimating the positions of defect and replacement. Further, available portions of the user data area and the spare area are located continuously, thereby enabling effective use of the user area. For this reason, additional data can be recorded or changed even after recording write protect information during disc finalization, and thus, disc defect management can be more effectively performed.

FIG. 11 illustrates data structures of temporary defect information *TDFL #0* and *TDFL #1*. Referring to FIG. 11, temporary defect information *TDFL #0* contains information regarding defects #1, #2, and #3. The information regarding defect #1 indicates the position of an area in which defect #1 exists and the position of an area in which replacement #1 is recorded. The information regarding defect #1 may further include information indicating whether defect #1 occurs in continuous defect blocks or a single defect block. Likewise, the information regarding defect #2 indicates whether defect #2 occurs in continuous defect blocks or a single defect block, the position of an area in which defect #2 exists, and the position of an area in which replacement #2 is recorded. The information regarding defect #3 indicates whether defect #3 occurs in continuous defect blocks or a single defect block, the position of an area in which defect #3 exists, and the position of an area in which replacement #3 is recorded.

Temporary defect information *TDFL #1* further contains information regarding defects #4 and #5 in addition to the information contained in temporary defect information *TDFL #0*. More specifically, temporary defect information *TDFL #1* includes the information regarding defect #1, the information regarding defect #2, the information regarding defect #3, the information regarding defect #4, and the information regarding defect #5.

FIG. 12 illustrates a data structure of information regarding defect #i. Referring to FIG. 12, information regarding defect #i includes state information indicating whether defect #i occurs in continuous defect blocks or a single defect block, a pointer to defect #i, and a pointer to replacement #i. When defect #i is determined to occurs in the continuous defect blocks, the state information further represents whether a pointer to defect #i points to the start or end of the continuous defect blocks and whether a pointer for replacement #i points out the start or end of a replacement block that replaces defect #i. When the state information indicates the pointer for defect #i as the start of the continuous defect blocks and the pointer for replacement #i as the start of the replacement block, the pointer for defect #i represents a starting physical sector number of the continuous defect blocks and the pointer for replacement #i represent a starting

physical sector number of replacement #i. In contrast, when the state information indicates the pointer for defect #i as the end of the continuous defect blocks and the pointer for replacement #i as the end of the replacement block, the pointer for defect #i represents an ending physical sector number of the continuous defect blocks and the pointer for replacement #i represent an ending physical sector number of replacement #i. The definition of continuous defect blocks using state information enables effectively recording of information and saves a space of recording, even if information regarding defects is not recorded in units of blocks.

The pointer for defect #i specifies a starting and/or ending point(s) of defect #i. The pointer for defect #i may include a starting PSN of defect #i. The pointer for replacement #i specifies a starting and/or ending points of replacement #i. The pointer for replacement #i may also include a starting PSN of replacement #i.

Hereinafter, a disc defect management method according to a preferred embodiment of the present invention will be described with reference to the accompanying drawings.

FIG. 13 is a flowchart illustrating a disc defect management method according to a preferred embodiment of the present invention. Referring to FIG. 13, a recording and/or reproducing apparatus records defect information regarding data, which is recorded according to a first recording operation, as first temporary defect information in a TDMA of a disc (operation 1301). This process serves to manage disc defects. Next, the recording and/or reproducing apparatus records management information for managing the first temporary defect information as first temporary defect management information in the TDMA (operation 1302). As described above, the first temporary defect management information drive & disc information, i.e., at least one of test location information or write protect information. Next, information regarding the locations of the first temporary defect information and the first temporary defect management information is recorded in a drive & disc information area (operation 1303). Then, the write protect information is further recorded in the drive & disc information area (operation 1304).

Next, it is checked whether disc finalization is required (operation 1305). If it is determined in operation 1305 that disc finalization is not required, operations 1301 through 1304 are repeated while increasing indexes given to a recording operation, temporary defect information, and temporary defect management information by 1 (operation 1306). However, if it is determined in operation 1305 that disc finalization is required, lastly recorded temporary defect management information and temporary defect information are recorded in a DMA (operation 1307). That is, the lastly recorded temporary defect management information and temporary defect information are recorded as final defect management information and defect information in the DMA, respectively. The final defect information and defect management information may be repeatedly recorded to increase the reliability of data detection. Further, the verify-after-write method may be performed on the final defect management information and defect information. If a defect is detected from this information, an area of the disc having the defect and the following area containing data may be regarded as being unavailable, i.e., they are designated as a defective area, and the final temporary defect management information and temporary defect information may be again recorded after the defective area. Alternatively, the write protect information, which is recorded in the drive & disc information area or included in lastly recorded temporary defect management information *TDDS#i*, may further be recorded in the DMA.

FIG. 14 is a flowchart illustrating a disc defect management method according to another embodiment of the present invention. Referring to FIG. 14, a recording and/or reproducing apparatus records user data in a data area of a disc in units of data to facilitate the verify-after-write method (operation 1401). Next, the data recorded in operation 1201 is verified to detect an area of the disc having a defect (operation 1402). Next, the controller 2 of FIG. 1 designates the area having the defect as a defective area, controls the recording/reading unit 1 to rewrite data recorded in the defective area to a spare area so as to create a replacement area, and creates state information specifying whether the defective area includes a single defect block or continuous defect blocks, and pointer information that points the positions of the defective area and the

replacement area (operation 1403). Next, the state information and the pointer information are stored as first temporary defect information (operation 1404). Next, it is checked whether the first recording operation is expected to end (operation 1405). If it is determined in operation 1405 that the first recording operation is not expected to end, operations 1401 through 1404 are repeated.

If it is determined in operation 1405 that the first recording operation is likely to end, i.e., when the recording of the user data is complete by user input or according to the first recording operation, the stored temporary defect information is read and repeatedly recorded as first temporary defect information *TDFL #0* in a TDMA several times (operation 1406). Next, management information for managing the first temporary defect information *TDFL #0* is recorded as first temporary defect management information *TDDS #0* in the TDMA (operation 1407). The first temporary defect management information *TDDS #0* further includes test location information and write protect information. Thereafter, a pointer to the location of the first temporary defect information *TDFL* #0 and a pointer to the location of the first temporary defect management information *TDDS #0* are recorded in a drive & disc information area of the disc (operation 1409). Alternatively, a pointer for temporary management information *TDMA #i,* other than the temporary defect information *TDFL #i* and the temporary defect management information *TDDS #i,* may be recorded in operation 1408.

Next, it is checked whether the data needs to be finalized (operation 1410). If it is determined in operation 1410 that the finalizing of the disc is not required, operations 1401 through 1409 are repeated. Whenever operations 1201 through 1207 are repeated, indexes given to a recording operation, temporary defect information *TDFL*, and temporary defect management information *TDDS* are increased by 1 (operation 1411). If it is determined in operation 1410 that the finalizing of the disc is needed, lastly recorded temporary defect information *TDFL #i* and temporary defect management information *TDDS #i* are recorded as final defect information *DFL* and the final defect management information *DDS* in a DMA (operation 1412). Recording of the final defect information *DFL* and the final defect management information *DDS* may

be repeated several times to increase the reliability of data detection. Similarly, the verify-after-write method may be performed on the final defect information and defect management information. If a defect is detected in this information, an area of the disc having the defect and the following area containing data may be regarded as being unavailable, i.e., they are designated as a defective area, and the final temporary defect management information and temporary defect information may be again recorded after the defective area. Alternatively, the write protect information, which is stored in the drive & disc information area or included in lastly recorded temporary defect management information *TDDS #i*, may further be recorded in the DMA.

[Effect of the Invention]

As described above, the present invention provides a disc defect management method applicable to write once discs. According to the present invention, at least one temporary defect information area is present in a lead-in area of a disc and/or a lead-out area, so that information regarding a defect that exists in the disc can be accumulatively recorded. Also, it is easy to finalize the disc by reading only lastly recorded temporary defect information from a temporary defect information area and recording the read information in a defect management area, thereby enabling effective use of the DMA. Accordingly, user data can be recorded even on write once discs while performing disc defect management, thereby allowing backup operations to be performed without interruptions.

According to the present invention, it is possible to change write protect information or perform disc defect management even after recording the write protect information in a disc.

Also, according to the present invention, even if a disc drive does not access a drive & disc information area and test location information or write protect information is not obtained, temporary defect management information further includes the test location information and the write protect information. Accordingly, it is possible to directly access a test area and prevent data from being recorded in an improper area.

In addition, it is possible to increase the reliability of a system by recording the test location information and the write protect information as temporary defect management information even if a user does not desire to perform disc defect management.